Section 4 — Pavement Rehabilitation Process

Section 5 — Summary of UDOT Standard Parameters

The following values are standard parameters used for UDOT pavement designs. Deviations from these standard parameters will need to be cleared with the Region Pavement Management Engineer prior to design submittal.

Design Inputs

Rigid Pavements

Design Life	40 years
Reliability	95% (Interstate) 90% (Other Routes)
Standard Deviation	0.35
Initial Serviceability	4.5
Terminal Serviceability	2.5
Modulus of Subgrade Reaction	Based on (CBR Value * 1,500) (15,000 psi maximum)
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	4,000,000
Mean Effective k-value	450 psi (Interstate) 300 psi (Other Routes)
Load Transfer Coefficient	3.0 Tied 4.0 Untied
Drainage Coefficient	1.0 or less

Flexible Pavements

Design Life	20 years
Reliability	95% (Interstate) 90% (Other Routes)
Standard Deviation	0.45
Initial Serviceability	4.2
Terminal Serviceability	2.5
Modulus of Subgrade Reaction	Based on (CBR Value * 1,500) (15,000 psi maximum)
Drainage Coefficient	1.0 or less

Layer Structural Coefficients

Plant Mix Seal Coat	0.30
Asphalt Concrete Pavement (Dense Graded)	0.40
Cold Mix Recycled Asphalt Pavement	0.25
Lean Concrete Base	0.28
Untreated Base Course	0.10
Granular Borrow	0.08

Recommended Layer Thicknesses

Plant Mix Seal Coat (PMSC)	1.0"
Asphalt Concrete Pavement (Total Thickness)	2.5" min.
Asphalt Concrete Pavement (Lift Thickness)*	2.0" min., 4.0" max.
Untreated Base Course	4.0" min.
Granular Borrow	6.0" min.
Portland Cement Concrete Pavement	9.0" min.
Lean Concrete Base	4.0" min., 6.0" max

* The minimum lift thickness should not be less than two times the largest size aggregate.

Introduction

In 1986 the FHWA Region 8 headquarters issued a significant change with Policy 86-1 This regional policy detailed the type of analysis and the documentation required to support the design of Federal-aid pavement rehabilitation projects. In implementing this policy the Utah Division established August 1, 1986 as the effective date. All Federal-aid projects would have to comply with the reporting requirements of Policy 86-1. With the issuance of Policy 86- l, which outlined the required data, analysis, and documentation for pavement rehabilitation projects, the pavement design reports are required to be more structured. This report is outlined in the "86-l *Report"* or *"Pavement Rehabilitation Report".*

Statewide Transportation Improvement Program

The Utah Department of Transportation's Statewide Transportation Improvement Program (STIP) is a three-year program of highway and transit projects for the State of Utah. It is a compilation of projects utilizing various federal and state funding programs including highway projects on the state, city, and county highway systems, as well as projects in the National Parks, National Forests, and Indian Reservations.

The current output document of the long range planning process is the "Utah Highway Needs Inventory". Each year projects are selected from the needs inventory to be considered for inclusion in the STIP. Short range studies, department strategies, required management systems, recommendations from the Regional Pavement Management Teams and Enhancement advisory Committee are some of the tools used to help select projects for the STIP. Proposed projects are then balanced with funds available for each program to determine the final selection.   A period of time for public notification and opportunity to comment on the proposed STIP is provided each year before it is finalized and adopted by the Transportation Commission.

Pavement Evaluation

The overall objective of pavement rehabilitation design is to provide a cost effective solution that addresses the deficiencies of the pavement and that meets all of the imposed constraints such as available funding and Constructability. This goal cannot be achieved without conducting a thorough pavement evaluation to determine the cause and extent of deterioration. This requires systematic data collection and an analysis of the structural and functional condition of the pavement as well as several other factors.

Pavement rehabilitation design is a very complex engineering task, often requiring more engineering than new design. However, in the past this part of a project has often been emphasized the least. Spending a little more time and effort to adequately evaluate and design a rehabilitation project will more than pay for itself in savings in initial construction costs and in future maintenance and rehabilitation costs.

A very good analogy would be the evaluation of a pavement prior to rehabilitation is similar to evaluating an automobile for repair. Prior to replacing a used car, the condition of the car, including its structural condition (motor, transmission, chassis), its functional condition (paint, interior, corrosion), and various individual components should be evaluated. The extent of deterioration can be assessed and either a cost effective repair and preventive maintenance plan can be developed (combining the information in all the different areas), or a decision made to replace the car. Even if the car is driven every day, it is still necessary to perform such an overall evaluation. The consequences of neglecting such an evaluation could result in a very poor and expensive decision.

A pavement rehabilitation survey is prepared by the Regional Pavement Management Engineer or Pavement Design Consultant for all resurfacing or rehabilitation projects. Consultants performing work for the Department are required to attend an "initial design-concept meeting" prior to performing any project specific design work. During this meeting, there will be a great deal of discussion on project concept, design input values, pavement testing plan, design life, etc.. All of which must be adhered to in order to produce a UDOT acceptable design.

After the required “initial design-concept meeting”, a pavement condition report is required. This is know as activity 25C in the PPMS system. This report is usually supplies very general data about the condition of the pavement. The format for this report is as follows:

Pavement Condition Report Format

I. Materials Evaluation.

A. Subgrade/Soil:

System level FWD data subgrade evaluation.
Representative CBR value or CBR value from construction history if available.
Soils information from original construction if available.

Detailed project level subgrade/soil data will be collected during pavement design (project level FWD testing/actual soils tests).

B. Roadway section:

Original construction layer thickness information and construction year.
Rehabilitation layer thickness information and construction year.
Maintenance treatment history.

Detailed project level roadway section data will be collected during pavement design (coring/trenching/ground penetrating radar).

C. Pavement condition:

From systems data (detail data sheets), report the following:

- IRI data
- cracking information
- FWD data
- skid data

Overall current condition rating.

Detailed project level pavement condition data will be collected during pavement design (cracking/coring/trenching/viscosity/density/air voids/ asphalt content/aggregate gradation/creep/permanent deformation).

II. Expected Traffic.

List expected traffic (design ESALs) from Project Traffic Information sheets if available; otherwise, estimate the expected traffic (design ESALs) from AADT data.

III. Project Alternatives.

The following preliminary designs are based on assumed values for the existing pavement structural strength. The values assumed are conservative. Project level FWD testing needs to be conducted in order to better evaluate the condition of the existing pavement.

A. Possible Alternatives

List alternatives and costs.

B. Engineering Analysis For Each Alternative

Do a preliminary life cycle cost analysis.

C. Select The Appropriate Alternative

Attachments:

detail data sheets
original construction soils information if available
original construction cross section if available
project traffic information if available
preliminary pavement design calculations for each alternative
life cycle cost analysis

The need for a complete and in-depth analysis of existing conditions cannot be over emphasized. Before appropriate rehabilitation alternatives can be determined and selected, it is imperative that the type of pavement distress be identified and the factors causing the distress determined. Once alternative rehabilitation strategies have been identified and analyzed and the most appropriate technique selected, the resulting rehabilitation project must be " engineered" just as thoroughly as a new construction project.

A pavement rehabilitation project usually deals with existing pavements which show obvious signs of distress or failure. As a result, the amount of data acquired for each survey may vary in both quantity and detail, depending on the condition of the roadway and the amount of data on file. The survey should be oriented toward analyzing the existing roadway conditions so that a reasonable definition of the special problems and structural needs of the roadway can be made. A pavement condition needs to be characterized in measurable terms so that future performance can be related to a defined condition.

By applying the tactics discussed above and reporting the findings in the following format, the engineer will furnish the required documentation necessary for rehabilitation strategy selection.

86-1 Report or Pavement Rehabilitation Report

I. Establish existing pavement condition

A. Identify the Distress

1. **Determine rideability and all surface distress.** Roughness is a common and important indicator of pavement riding comfort and safety. It is a measure of a pavement's functional performance. It is the number one taxpayer's concern, whether it is the trucking industry or the general traveling public. Excessive roughness can cause increase vehicle operating costs as well as creating user discomfort. When discussing the customer satisfaction, the quality of the ride is the number one performance measure in pavement management. The "International Ride Index" or IRI, measured

in inches/mile, is computed as the cumulative movement of the suspension of the quarter-car system (QCS) divided by the traveled distance. The model simulates a quarter-car system, traveling at a constant speed of 80 km/hr. This value provides an indicator of the ride quality. It provides a numerical value to represent the ride or "smoothness" that a particular pavement section provides.

The results of a roughness survey will be used to aid in the selection and design of feasible rehabilitation alternatives. If a specific project exhibited a short section of pavement severe roughness and the rest of the project exhibited minor roughness, the rehabilitation strategies might be different for the two sections. It is also useful in quantifying the ride quality along a project before and after rehabilitation activity. Roughness is also a useful tool in evaluating the quality of a contractor's construction for resurfacing and reconstruction.

IRI Pavement Condition Scale		
	Bituminous	**Concrete**
Very Good	0-45	0-85
Good	46-70	86-110
Fair	71-100	111-140
Poor	101-135	141-175
Very Poor	>135	>175

2. **Visual walk through of pavement section.** The Pavement Distress Evaluation will be conducted to identify specific distress types, severities, and quantities. The distress evaluation as well as the pavement geometrics will be compared at this time to the accident history of the pavement section to determine if there is any relationship. The distress evaluation provides valuable information used to determine the cause of the pavement deterioration, its condition, and eventually its rehabilitation needs. The distresses will need to be classified on cause: (1) load related, (2) moisture related, (3) temperature/climate related, (4) material related or a combination thereof. Pavement drainage should be evaluated closely. If moisture is accelerating pavement deterioration the engineers must determine how the water is accelerating the deterioration, where it is coming from, and what can be done to prevent or minimize it.

   A pavement section requiring rehabilitation will include a "walk through" pavement survey. This survey will require an accurate account of existing pavement distress and drainage observations. The pavement distress survey, as defined by the "SHRP Distress

Identification Manual"' must quantify the type, severity, and extent pf pavement surface distress types found on project. It will map all existing pavement, providing the most accurate pavement section data. The types of distress types to be collected are as follows:

Guideline For Classification of Flexible Pavement Distress Types

Flexible Distress	Probable Causes	Struct.	Funct.
Fatigue/Alligator Cracking	Load Moisture/Drainage	x	s
Block Cracking	Climate/Durability	x	s
Edge Cracking	Load	x	s
Longitudinal Cracking	Climate/Durability	x	s
Transverse Cracking	Climate/Durability	x	s
Rutting	Load/Materials Moisture/Drainage	s	x
Shoving	Load	s	x
Bleeding	Materials Climate/Durability		x
Polished Aggregates	Materials/AADT		x
Raveling	Climate/Durability	x	x
Skin Patching	All	x	x
Pothole/Pothole Patching	Load/Climate/Other	x	x
Lane-to-Shoulder Drop off or	Moisture/Drainage Materials		x
Water Bleeding and Pumping	Moisture/Drainage	x	x
Corrugation	Load/Materials		x
Swelling	Moisture/Drainage &	x	x
Depression	Load Moisture/Drainage		x
*Other			

x = distress type has an effect
s = the effects depend on severity level

Guideline for Classification of Concrete Pavement Distress Types

Rigid Distress	Probable Causes
Corner Breaks	Load
Durability Cracking	Climate
Transverse Cracking	Load/Climate
Longitudinal Cracking	Load
Transverse Joint Seal Damage	Climate/Other
Longitudinal Joint Seal Damage	Climate
Spalling of Longitudinal Joints	Climate/Durability Other
Map Cracking	Other
Scaling	Other
Polished Aggregates	Other
Pop outs	Other
Blowups	Climate
Faulting of Transverse Joints	Lack of Load Transfer
Lane-to-Shoulder Drop off	Other
Lane-to-Shoulder Separation	Other
Water Bleeding and Pumping	Moisture/Drainage
Reactive Aggregate Distress	Materials
*Other	

Once the distress types are determined and classified by extent and severity, carefully written definitions of the distress appearance should be prepared and, in some instances, supported by digital photographs in the submitted pavement designs. When available, this data will be supplemented by the system level data collected by DOT's Planning Division. This data includes information in addition pavement surface distress such as IRI, Skid, Structural Integrity, etc.

3. **Develop testing plan to provide engineering data for decision making**

A testing plan must be established during a Pre-Concept Meeting. This meeting will include representatives from Region Materials, and Pavement Design Consultant (if deemed necessary) and any other individuals identified with project pertinent information. The group will evaluate the pavement section and analyze all available data in order to establish a materials/pavement testing plan which will provide enough information for a project level pavement design to be completed.

The following table is a general guideline for recommended testing on specific pavement rehabilitation projects. This testing guideline is not inflexible nor is the testing limited to data items. The destructive and nondestructive testing expand into a multitude of scenarios.

Data Item	Full-	Partial-	Overlay	Grinding	Recycling	Under-	Subdrains	Joint	Load	Surface
Pavement	X	X	X	X	X	X	X	X	X	X
Original			"	"	"		"	"	"	
Age	"	"	"	"	"		"			"
Materials	"	"	X	X	X	"	X			
Subgrade			X		X	"	X	X		
Traffic	X	X	X	X	X	"	X	"	X	X
Distress	X	X	X	X	X	X	X	X	X	X
Skid			X	X	X					X
Accidents			"	"	"					"
NDT/FWD			X		X	X			X	"
Destructive	"	"	X	"	X	"	X		"	
Roughness	X	X	X	X	X			"	X	"
Surface			"	X						X
Drainage	X		X	X	X	X	X	X		"
Previous	"	"	"	"	"	"	"	"		"
Utilities	X		X		X	"	"			
Traffic	X	X	X	X	X	X	X	X	X	X
Vertical			X		X					
Geometrics			X		X					

X Definitely needed
" Desirable
(Blank) Not Normally Needed

The information gathered from this testing plan will provide the Regional Pavement Management Engineer the ability to ensure the proper resource allocation for project funding at the Concept Meeting.

4. Nondestructive Testing (NDT), Pavement Deflection Basin Structural Analysis with back-calculated moduli

The existing pavement structural analysis is performed on all selected structural overlay projects by the Regional Pavement Management Engineer. This analysis should be conducted at the concept phase of the project for all pavement overlay candidates to aid the Regional Materials Engineer in his rehabilitation strategy selection. The Regional Pavement Management Engineer should coordinate with the Central Planning Division so that most of the deflection surveys are conducted during the same time period each year. Cores should be taken to verify the construction history pavement thickness for analysis. After conducting the deflection surveys, the Regional Pavement Management Engineer will report the results of this analysis along with recommendations to further investigate any variations that might point to a localized problem, such as a soft subgrade spot, poor compaction around a culvert, etc. Defection surveys should also be conducted on PCC pavement to establish load transfer across joints and if necessary for void detection.

The estimate of the load-carrying capability and the structural service life under the projected traffic condition of the pavement section must be taken into consideration. UDOT uses a nondestructive testing method for evaluating the structural integrity of a pavement section. This method is performed using Falling Weight Deflectometer (FWD) deflection testing data. In most cases, FWD testing will be identified as part of the pavement rehabilitation testing plan. Using the deflection data generated by the FWD, a pavement deflection basin structural analysis, following UDOT's guidelines, will provide the pavement section's ability to carry projected traffic loadings and determine the required pavement overlay. This analysis will also include the pavement sections layer moduli values. The moduli will be back calculated in the deflection basin structural analysis and used to evaluate individual pavement layer performance. The moduli aid the engineer in identifying the pavement layers where structural deficiencies are located. The deficiencies could be in the bituminous, untreated base, granular borrow layers or in the existing subgrade, the point being that the information provided is critical information for the rehabilitation decision.

One must keep in mind that a deflection basin structural analysis, does not identify early stages of stripping susceptible asphalt mixtures or rutting susceptible asphalt mixtures. The materials investigation must always be taken into consideration with the deflection basin structural analysis to more accurately project structural integrity. Project specific pavement rehabilitation concepts such as spot repairs, HMA removal and replacement and structural overlays will all be directly impacted in the decision making process by the pavement deflection basin structural analysis.

5. Destructive Testing (DT), Coring and Trenching:

Coring: Destructive testing should be used to supplement Nondestructive testing to provide the necessary project level information needed for pavement rehabilitation. It is desirable to combine limited destructive testing within

NDT to achieve the most accurate results. For accurate back-calculation of the layer properties, it is necessary to determine the exact layer thickness in the locations where NDT results are going to be used for back-calculating. Coring provides exact layer thicknesses. Coring also allows the engineer to determine if and where stripping susceptible asphalt layers lie in the pavement section.

Trenching: The destructive testing umbrella covers trenching as well as coring. Trenching consists of cutting a full depth, 4 to 6 inch wide strip of pavement, full width of a traffic lane and pulling it out to observe the performance of the different pavement layers over time. If rutting is present, it allows the engineer to determine if the rutting is from consolidation or plastic flow. If plastic flow exists, this method allows the engineer to determine the actual depth that plastic flow is taking place.

To determine if plastic flow is present by this method, place a string line horizontal to the pavement layer, beginning at the top construction lift or layer interface and observe whether or not there is deformation in the wheel paths at this interface from traffic loading. Proceed down each construction lift until no deformation is visible. This provides the engineer the depth of unstable material. This is a faster, more accurate and cheaper process than running project level creep and deformation testing, using the results to plug into computer models to determine viscoelastic characteristics of the asphalt mixture. Trenching also allows the engineer to determine if and where stripping susceptible asphalt layers lie in the pavement section.

6. Establish Portland Concrete Cement (PCC) Pavements Joint Condition

Typical types of joint seal damage are:
- stripping of joint sealant
- extrusion of joint sealant
- hardening of the filler (oxidation)
- loss of bond to the slab edges (adhesive failure)
- splitting of joint sealant material itself (cohesive failure)

Joint sealant damage is any condition that allows the intrusion of incompressible or the infiltration of water. The intrusion of incompressible will not allow slab expansion which can result in surface spalling and blow-ups. The assessment of joint condition is based on overall condition of the pavement section. The joint condition will be evaluated according to the SHRP distress Identification Manual to categorize the joint sealant distress levels for severity and extent.

7. Any other destructive or non-destructive testing deemed necessary

Every pavement section to be rehabilitated is individually unique in its performance characteristics. Additional testing may be necessary, depending upon the pavement condition, types of distress and the forecasted project concept. This additional testing will be identified on a project by project basis which can include, but not limited the following: Hot-mix asphalt recycle design, cold-mix asphalt recycle design, SHRP asphalt grade testing, asphalt viscosity testing, gradations stripping susceptibility testing, accelerated rutting testing, ground penetrating radar, PCC petrographic analysis, etc.

8. Identify and map all PCC partial and full depth repairs:

Each Portland Concrete Cement pavement to be rehabilitated must have a detailed, panel by panel condition assessment, identifying and mapping all partial and full depth repairs necessary to restore the existing pavement to an acceptable condition. The partial and full depth PCC repairs must have estimated material quantities which include an additional 25% inflationary adjustment which will cover the progression of the distress for the period of time between project design and actual field construction. The PCC rehabilitation strategy must also include grinding in order to restore the ride quality to an acceptable level.

9. PCC load transfer analysis and void detection.

Load transfer information can be very beneficial in the analysis of a pavement section. The faulting rate, load transfer efficiency, structural condition, existing pavement distress and remaining life must all be taken into consideration to determine the proper pavement strategy to be selected.

Load transfer restoration is the installation of load transfer bars after the initial pavement construction to transfer load and reduce the variation in deflection across transverse joints or cracks to retard further pavement deterioration due to joint pumping, faulting, spalling , and subsequent cracking. The ability of a joint or crack to transfer load from one side joint to the other is referred to as its load transfer efficiency (LTE).

Load transfer across a transverse joint or crack will be determined using FWD testing and following UDOT LTE procedural guidelines. The basic concept of load transfer efficiency equals the deflection of the unloaded side of the joint divided by the deflection of the loaded side of the joint, multiplied by 100.

A load transfer restoration project may be performed on an existing JPCP that is structurally sound but is experiencing pumping and/or faulting. It is recommended that the estimated remaining structural life of a load transfer retrofit candidate project be a minimum of ten to twelve years.

Under sealing projects will be rare for PCC pavements in Utah. Void detection in PCC pavements will rarely be requested.

10. Current annual data from planning for pavement design.

All project traffic information will be requested through the Utah Department of Transportation for all state routes where traffic information is available. These will be written requests using the Traffic Request Form F-1. The requests will be through your Regional Pavement Management Engineer via the Planning Division's Statistical Engineer. The traffic information will be supplied in most cased by the department, but there will be a number of limited projects that UDOT will not have the desired traffic information. It will be these projects that require manual project design ESAL calculations to be performed by the design consultant. If the design ESAL calculations are to be performed by a consulting agency, it will be coordinated and approved through the Regional Pavement Management Engineer following UDOT guidelines.

Pavement distress data will be used to assess pavement section condition. Current pavement distress as well as pavement distress history collected by the Planning Division will be used to identify pavement section performance by plotting distress type versus time for each distress type to determine each pavement section failure modes by determining each distress indices deterioration rate. Performing deterioration analysis and detecting the possible initiation and source of each pavement distress allows the engineer to prescribe timely preventive treatments and repairs that address the source of the deterioration and just the symptoms.

B. Determine Cause of Distress

The distress data provides valuable insight into the mechanisms of pavement deterioration. As a first step, the distress can be identified as being either primarily load-associated or primarily climate/material associated.

If the distress is primarily load-associated, rehabilitation work should include a structural improvement. If climatic conditions or paving materials are contributing to the deterioration, appropriate measures should be identified to address those deficiencies or to lessen their impact or effect on pavement performance. If serious climatic or materials problems exist, the best solution may be a total reconstruction of the pavement section.

If pavement performance data is collected on a pavement section at different points in time, then information can be obtained regarding the time that the various distresses began to appear and their relative rates of progression. Such information can be extremely valuable in identifying causes of distress and in programming appropriate rehabilitation actions, for example determining if a specific pavement section can wait 3 years for an overlay or whether it will be too deteriorated.

An overall examination of the data along the project will reveal if there are significantly different areas of pavement condition along the project. For example, a change in subgrade, traffic, or materials may result in a significant change in pavement performance (which will show up in the occurrence of distress). In addition, the inner lanes of multilane facilities may exhibit significantly less distress or lower severity levels of distress than the outer lane. By recognizing these trends, rehabilitation designs can be varied along the project and/or across lanes to reduce costs.

The distress data should be summarized in order to provide a clear picture of the existing pavement. Analyze the identified distress and provide a brief explanation of the cause determined through engineering analysis. Provide an explanation of conclusions in report form.

C. Predict Remaining Life

1. Existing pavement condition

The existing pavement condition is an all inclusive section. Items to be documented includes such items as location, year constructed, design, available materials and soils properties from published reports and previous surveys, climate, pavement distress history, maintenance and construction history. Any previous performance data from pavement management studies or other pertinent data should be obtained and included.

2. Design 80 KN loads of the project

A complete traffic evaluation provides information on the estimation of past and current loadings on the structural adequacy of the existing pavement, and on the expected future traffic loadings. The consideration of the future traffic loadings can be an important part of rehabilitation planning and programming and may also influence the ultimate selection of the rehabilitation strategy. The collection of representative traffic data and the correct interpretation and analysis is critical in achieving a proper rehabilitation design.

3. Subgrade Type

Subgrade soils and pavement materials have a major impact on the design, construction, structural response and performance of a pavement. Unstable subgrade present problems in placing and compacting base and subbase materials and in providing adequate support for subsequent paving operations. Without an adequate working platform critical pavement construction details such as adequate compactive effort may not be accomplished within acceptable tolerances. In many cases this type of construction deficiency can cause pavement and profile deterioration after exposure to traffic and environment.

Pavement structural responses (stresses, strains, deflections) are also highly dependent on the subgrade support. A large percentage of the surface deflection of a pavement is a direct result of the support provided by the subgrade.

The desirable properties of a subgrade include adequate shear strength, adequate permeability, ease and permanency of compaction, volume stability, and permanency of strength.

AASHTO soil classifications, CBR or laboratory resilient modulus values are desirable and may be required depending upon the project concept and scope of work. NDT back-calculated subgrade resilient moduli will be required in most all rehabilitation cases. A distinction must be made in the subgrade back-calculated moduli between field moduli and laboratory moduli. Additional soil information could be beneficial may include Unified soils classification, dynamic cone penetrometer testing, permeability, expansive or collapsible soils testing, alkali reactivity information, etc.

4. Surface and subsurface drainage conditions

Surface and subsurface water has long been known to be the leading cause of pavement distress. The recognition of the amount, severity and cause of moisture related distress plays an important role in the rehabilitation scheme selection. Unless moisture related problems are addressed, the effectiveness of the rehabilitation decision will be reduced. A drainage evaluation must be performed in conjunction with the NDT analysis to identify existing moisture related problems and to identify the potential for moisture problems to develop within a pavement structure. A drainage evaluation includes a distress survey and an examination of the external and internal drainage factors that influence the moisture condition in a pavement.

5. Quality Control/Quality Assurance tests on previous projects

When possible, identify any material variation on pavement section from construction and maintenance materials testing records. Insight into pavement distress and materials problems can be gained through the analysis of the testing records as well as any records containing field notes concerning construction problems, material variability, etc. This information can dramatically effect the remaining life calculations for individual pavement sections and should be included as part of an explanation in the cause of distress.

6. Non-destructive and destructive testing data

Use NDT and DT to analyze the pavement section's probable deterioration mode to failure, estimate remaining life for deterioration failure mode, and engineer an appropriate pavement rehabilitation as discussed in previous and following sections.

7. Back-calculating total applied loads versus design loads

Use historical traffic data to calculate the accumulated 1 8-km (80 KN) equivalent single-axle loads (ESAL) for a pavement section following the traffic projection guidelines in the traffic section of the pavement design section.

The remaining structural life of pavement section will be estimated using this traffic data which will usually be supplied by the Planning Division. A complete traffic evaluation provides information on the estimation of past, current and expected future traffic loading.

By knowing the past and current traffic loadings comparisons can be made with the design traffic by allowing the engineer to back calculate the total ESALs applied to the pavement section versus the original design ESALs to provide an indication of the theoretical remaining life. This will provide a picture of how well the pavement is performing structurally and if a structural deficiency exists. This calculation will be an approximate figure, but it will provide the engineer a guide to be used in conjunction with destructive testing, non-destructive testing, construction history information, and deterioration curves to determine an approximate remaining life.

8. Pavement deterioration curve extrapolation

The year in which a pavement section deteriorates to unacceptable levels can be determined by extrapolating pavement deterioration curves for each pavement section to be rehabilitated.

The long-term rate of deterioration is determined by comparing a pavement section's deterioration rate with the expected deterioration rates of pavement sections that have the same pavement type (AC or PCC), rank (Interstate, primary, etc.) and level of traffic.

Deterioration for each distress type can be extrapolated to analyze remaining life for each. The remaining life calculated for each distress type then can be compared to the theoretical structural remaining life to identify the overriding mode of failure for the individual pavement section.

D. Establish future pavement needs

The pavement design period should include subject pavement performance, historical records on pavement performance, long term pavement management goals, corridor studies, future trucking haul routes, adequacy of traffic capacity, and safety performance of facility.

The design period will influence rehabilitation versus reconstruction.

Determine present truck weight using weigh in motion 48 hour sampling to determine actual present loads being applied to pavement as well as future needs of pavement structure. The Utah Department of Transportation follows FHWA's HPMS (Highway Performance Monitoring System) Requirements. This HPMS system requires the department to set up a statewide sampling frame. The volume is collected at over 5000 sites, with one third collected each year. At these sites the volume is collected for a minimum of 48 hours at each site. From these volume sites, 300 random sites were selected for a traffic classification count. Again, counts are performed over a three year period, with 100 of these classifications counts performed per year. Then in order to meet HPMS's requirements for collecting WIM data, 90 sites were selected out of the 300 classification sites in order to calculate truck factors for functional classes. It is this sampling process which produces the design factors and growth rates for volume, vehicle classifications and weigh-in-motions data for calculating equivalent single axle load factors for each vehicle classification to be used in our design process.

E. Develop Feasible Alternatives

The preferred rehabilitation strategy for a given project must be cost-effective, must address the specific problems of the pavement, and must meet any existing constraints of the project. The procedure for determining the preferred rehabilitation strategy is quite complex and will probably entail as much or more engineering judgement than engineering analysis when compared to new pavement design.

There is almost always more than one alternative rehabilitation design available for a given project. Each alternative has its own associated costs, Constructability, performance life, reliability, maintainability, and other unique characteristics. It is desirable to select the preferred alternative, or the one that meets all of the engineering criteria. The preferred alternative does not necessarily imply optimal, since the various constraints may not permit the optimization of the literal sense.

Several preliminary alternative designs can be developed that address the causes of the existing deterioration and prevent their reoccurrence. Feasible alternatives must include both repair and preventive techniques. The following are the guidelines:

Base line is reconstruction with the assumption other present pavement is beyond rehabilitation service life. This cost will serve as bench mark for all alternative analysis.

Rehabilitation should address aspects of correcting existing distress and provide additional service life.

Rehabilitation should address aspects of correcting existing distress and provide additional service life.

Rehabilitation strategy should have life expectancy of 5-20 years depending upon the pavement design strategy. The strategy implies that the design should be concerned with the pavement throughout the entire design or analysis period.

Alternatives should consider different strategies for shoulders or lanes depending upon distress survey data. It should also consider structural section alternatives as well as material type alternatives.

F. Conduct an engineering/economic analysis

All decision criteria, both monetary and nonmonetary, that will be used in selecting the preferred alternative must be identified. Engineering factors include such items as traffic control options, time of lane closures, material and equipment availability, and prevailing climatic conditions. Monetary factors include costs to the agency and to the user. A life-cycle cost analysis of each alternative then should be conducted that considers all relevant costs.

A. Economic analysis should be done following the guidelines in the Life Cycle Cost Analysis Section of this manual.

G. Select the appropriate alternative

Each rehabilitation alternative must be evaluated with respect to the selected criteria, and the preferred alternative must be selected considering all important decision factors before being recommended.

Once several distinct feasible alternatives have been developed, they must be evaluated and the preferred rehabilitation alternative selected. The preferred alternative must fit in with the overall pavement management of the Region and State. Funding for any given project is normally set in advance and usually cannot be significantly increased. The rehabilitation alternative that has the lowest total life-cycle cost of a given project may not coincide with the best interests of the entire pavement network, considering the limited availability of funds.

The selection of the preferred rehabilitation alternative may be dictated by some overriding considerations, such as traffic soils, climate, traffic control during construction, lane closures, available materials and equipment, and overall pavement management considerations. Other examples of constraints that may affect the selection of alternatives are:

- Limited project funding
- Traffic control requirements
- Minimum desirable life of rehabilitation
- Future maintenance requirements
- Geometric design problems
- Utilities
- Right-of-way restrictions
- Available materials and equipment
- Contractor expertise and manpower
- Agency policies

These factors must be considered in the selection of the preferred rehabilitation strategy. Consideration should be given to how a rehabilitation strategy may affect the network as a whole. It may occasionally be necessary to select an alternative that is not optimal for a project because of overall network constraints.

The “86-1" report with the selected pavement design prepared or approved by the Regional Pavement Management Engineer will be included in the project design study report.

H. List of attachments for report

The following things should be included with the 86-1 report:

detail data sheets
project level distress survey
original construction soils information if available
soils information (design CBR calculations as a minimum)
original construction cross section if available
coring information if available
FWD data and analysis if available
project traffic information
pavement design calculations for each alternative
design charts if used
frost penetration map
initial cost estimates for each alternative
life cycle cost analysis
high and low temperature maps for PG asphalt